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INDUCED VOLTAGE/LIGHTNING PROBLEMS AT USAF BRANDYWINE AND DAVID--ETC(U)
JAN 79 R VINASSA, J F ZYCH

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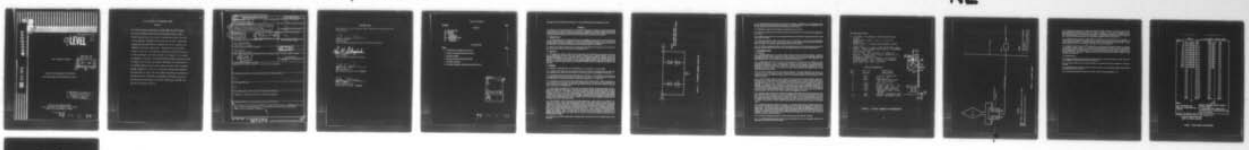

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AFCS TECHNICAL REPORT

INDUCED VOLTAGE/LIGHTNING PROBLEMS AT USAF BRANDYWINE AND DAVIDSONVILLE SITES

SUPPORT ENGINEERING BRANCH
1842 ELECTRONICS ENGINEERING GROUP (AFCS)
SCOTT AIR FORCE BASE, ILLINOIS

19 January 1979

1842 ELECTRONICS ENGINEERING GROUP

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As a result of the survey performed at subject USAF sites, recommendations are made to decrease vulnerability to lightning which have been destroying communication equipment components.

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This report has been reviewed and is approved for publication and distribution.

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INDUCED VOLTAGE/LIGHTNING PROBLEMS AT USAF BRANDYWINE AND DAVIDSONVILLE SITES

SUMMARY

As a result of site surveys performed 19-21 Sep 78 at USAF sites located in Brandywine and Davidsonville, MD, recommendations are made to decrease the vulnerability to lightning and induced voltages due to lightning which have been destroying communication equipment components at the sites. With the implementation of the recommendations contained herein, the number of component failures should be greatly reduced.

1.0 INTRODUCTION.

1.1 The 2045 Comm Group at Andrews AFB has been attempting for several years to resolve lightning and induced voltage problems at the Brandywine Receiver and Davidsonville Transmitter Sites. After numerous attempts to have the Base Civil Engineer correct the problems, a request for technical assistance was sent to HQ AFCS/EPC. The 1842 EEG was tasked to provide technical assistance to the 2045 CG.

1.2 Messrs. Remo Vinassa and John Zych of the 1842 EEG were assigned to the task and on 19-21 Sep 78 site surveys were performed at the Davidsonville and Brandywine sites.

2.0 ANALYSIS.

2.1 The lightning and induced voltage problems at Brandywine and Davidsonville were analyzed by reviewing past correspondence, discussions with site personnel concerning their attempted solutions, and on-site equipment investigations. The investigations consisted of physically inspecting and checking rhombic, log periodic (RLP)and Monocone antennas at the sites. Rhombic supporting towers were inspected for lightning protection. In addition, existing rhombic antenna lightning protection devices, open wire transmission lines between the transmit rhombic antennas and the transmitter building, and all tower grounding connections were inspected.

3.0 FINDINGS.

3.1 Brandywine. Based upon an on-site investigation, the following items were found:

3.1.1. Existing TMC coupler boxes on the rhombic antennas were opened and lightning protection spark gaps were checked to see if they were within tolerance. In almost every case, the spark gaps were set too wide.

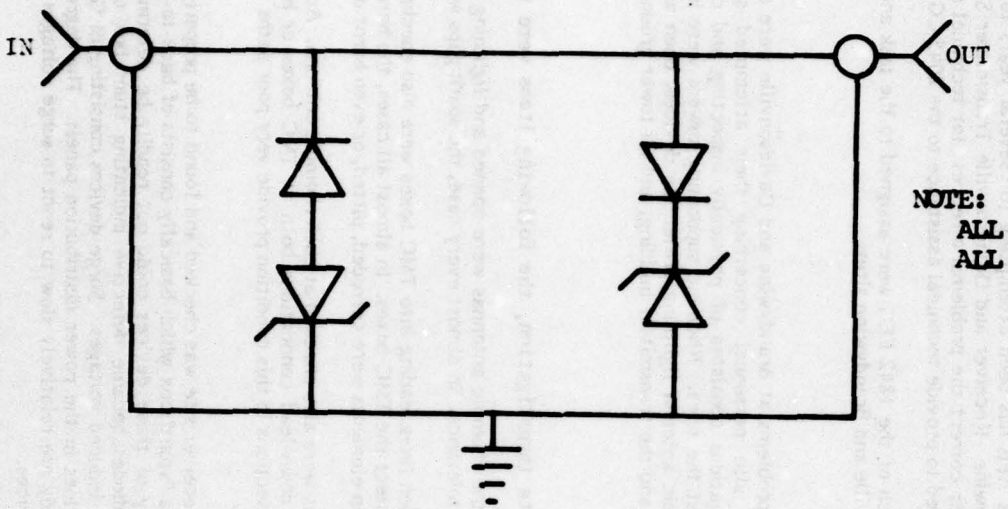
3.1.2 Lightning protection on transmission lines leading into TMC boxes were also checked. At each down lead a horn gap assembly was installed to protect the TMC boxes. In almost all cases, the horn gap was not adjusted to specifications. In some cases, horn gap elements were corroded, pitted, or even burnt off.

3.1.3 Grounding connections and systems were also checked at each rhombic antenna. Adequate grounding rods were installed, but in many cases the down-lead connections both at TMC boxes or horn gap assembly and ground rod were loose or corroded. Connections in this condition provide very poor paths to ground for lightning and may contribute to existing problems.

3.1.4 The RF cable entry plate at the receiver site was checked and found to be properly grounded. RF inputs to the multicouplers were protected by a "stunt" box which basically consists of back-to-back diodes and zener diodes (see Figure #1). The adequacy of these devices could not readily be determined; however, during lightning storms, some of the zener diodes became defective indicating stunt box operation and possibly providing some type of protection from induced voltages. Surge devices consisting of GE home type lightning arresters were installed on the power lines in the power distribution panels. The degree of protection these devices provide is questionable since they are relatively slow to react to surge voltages and therefore provide inadequate protection for solid state devices.

3.1.5 RLP antennas 7, 8 and 9 were checked for lightning protection. These antennas are connected to the Scope Control system. Radio maintenance personnel indicated a considerable number of diode failures were occurring in the matrix control rack during lightning storms. Diode failure usually resulted in a continuous rotation of the affected RLP antenna. To eliminate this problem, the diodes were relocated to removable PC boards. The PC boards are usually removed during lightning storms. The diodes act as isolating devices and are used only for azimuth display purposes on the matrix control rack. Further inspection revealed diode failure only on RLP antennas 7 and 8. The remote control cables leading from each antenna to the interior of the building were inspected. Remote control cables for antennas 7 and 8 were unshielded. Antenna #9 had a shielded remote control cable. It is evident that in this case a shielded cable does provide protection from lightning induced voltages.

3.1.6 Inspection of the TMC coupler boxes on antennas RHE-1B (Germany) and LG-2A (Lajes) showed cracked insulators.



NOTE:
ALL DIODES ARE IN4004
ALL ZENER DIODES ARE IN3824A

FIGURE 1. RF OVERLOAD ASSEMBLY (STUNT BOX)

3.1.7 It was also found that the desiccant in several of the TMC boxes was placed on or near existing spark gaps and may have interfered with the spark gap operation. Desiccant application was not standardized in the rhombic antennas; e.g., some TMC boxes had desiccant while others did not.

3.2 Davidsonville. Based on site investigation, the following items were found:

3.2.1 The horn gap arresters above the balun transformers were checked and in most cases the existing gap was set too wide.

3.2.2 Grounding wire connections for the horn gap arresters, balun transformers, and ground rods were, in some cases, loose or corroded.

3.2.3 Spark gap assemblies on balun transformers were out of specifications. In most cases, the gap between arrester and case was too wide. Also, in some cases, the gap material used was incorrect (J-bolts) or incorrectly aligned. If incorrectly aligned, lightning protection is non-existent.

3.2.4 The Monocone lightning protection system (curved pieces of metal at the base of the antenna forming a spark gap) should be adjusted for 0.5 inches. The wider gap specified by the T.O. is for 50 kW operation.

4.0 RECOMMENDATIONS.

4.1 Brandywine.

4.1.1 Lightning protection for all existing rhombic antennas should be checked for adequacy. Horn gap assemblies situated above balun transformers should be checked to insure that a 1/16 inch horn gap separation is maintained IAW AFTO 31-10-22, Figure 2-19. Missing assemblies must be replaced. Spark gaps inside TMC boxes should be set for 1/32 inch spacing IAW the instructions in the box cover.

4.1.2 All grounding connections from the horn gap assemblies and TMC boxes must be checked for tight, corrosion-free connections. Similar connections must also exist at all ground rods. It is recommended that during PMI, all grounding connections be disassembled, cleaned with fine sandpaper and appropriate cleaning chemicals such as AFCS CAT # 8630, and sealed with an approved corrosion prevention compound such as NO-OX-ID grease, AFCS Cat #8440. This will insure a good corrosion resistant joint ideally suited for good grounding and lightning protection.

4.1.3 The receiver building should be protected from lightning. The highest object near this facility is a microwave tower with an existing antenna. Recommend two air terminals be installed above this existing antenna with minimum #2 AWG down-conductors and the down-leads be connected to the existing microwave tower ground system.

4.1.4 A 1/2 inch diameter copper (or copper clad) air terminal and minimum #2 AWG stranded copper down-lead (connected to a ground rod) should be provided on each rhombic tower. At present, the obstruction light is the highest object on the tower and its associated conduit and power cable feed are primary paths to ground when lightning strikes the tower. Power panel #157, located within the receiver building, was damaged by lightning. It is theorized that the damage to the power panel was a result of lightning striking the tower obstruction lights, following the power line back to the building and entering the power panel. Installation of an air terminal, IAW existing lightning protection codes; e.g., UL96 or NFPA #78, is the primary lightning protection recommended for these high objects. Codes should be checked for the proper type of materials and further information. See Figure #2 for further information and suggested installation.

4.1.5 Additional surge protection devices should be installed at TMC boxes and at the RF multicoupler inputs. These devices are listed in Figure #3. Devices to be installed in the TMC box will be prototyped by the 1842 EEG. Recommend that the initial installation be coordinated with NCA and the actual installation be witnessed (and engineering assistance provided) by the co-authors of this report. It is also recommended that a ground rod be carefully driven directly outside and opposite the cable entry plate at the receiver site and the plate connected to the ground rod. The new ground rod should provide a more direct path to ground for existing RF cables.

4.1.6 Existing procedures for backup power-transfer for obstruction lights should be changed during storms. Recommend obstruction lights remain on commercial power and only electronic equipment be transferred to backup power. The obstruction lights are the highest object on the towers and lightning is attracted to the highest object. With present backup procedures a path is formed by cable and conduit leading from tower to facility and if lightning hits obstruction lights, lightning may follow this route into facility. Since electronic equipment is fed from the same panel as the obstruction lights damage may occur at this panel or feed into equipment and disrupt equipment operation.

4.1.7 All TMC boxes should be checked for cracked insulators and cracked insulators replaced.

4.1.8 A standardized procedure and location should be established for the use of desiccant; otherwise, the requirement for the desiccant should be deleted.

ENGINEERING NOTES:

1 CUT ITEM 1 TO PROTRUDE ABOVE OBSTRUCTION LIGHTS.
2 THREAD ITEM 1 WITH A 3/4" - 10 THD FOR MOUNTING.
3 ATTACH ITEM 1 TO TOWER WITH HARDWARE ITEMS 4, 5, & 6.
4 ATTACH ITEM 2 TO ITEM 1 WITH EXOTHERMIC WELD, ITEM 3. OTHER CONNECTIONS SUCH AS A GROUNDING CLAMP MAY BE USED.
5 USE OF ITEM 7 FOR ATTACHING TO TOWER IS TYPICAL. OTHER ITEMS SUCH AS STRAPPING KIT, ITEM 8, IS ACCEPTABLE.
6 RECOMMEND GROUND BE CONNECTED TO EXISTING GROUND SYSTEM. ITEM 3 SHOULD BE REPLACED WITH ITEM 8 FOR THIS SITUATION.

LIST OF MATERIALS

ITEM NO	LIST OF CAT NO.	MATERIALS DESCRIPTION
1	8219	3/4"x10' GROUND ROD
2	4569	WIRE, #2 AWG
3	8353	EXOTHERMIC WELD, 3/4" ROD, #2 AWG WIRE
4	3574	NUT, 3/4" - 10
5	3765	WASHER, LOCK 3/4" - 10
6	3759	WASHER, FLAT 3/4" - 10
7	3468	CLAMP, CABLE LASHING
8	9359	EXOTHERMIC WELD, T-CONNECTOR
9	8498	IGNITER, EXOTHERMIC WELD
10	8499	FLINTS, EXOTHERMIC WELD

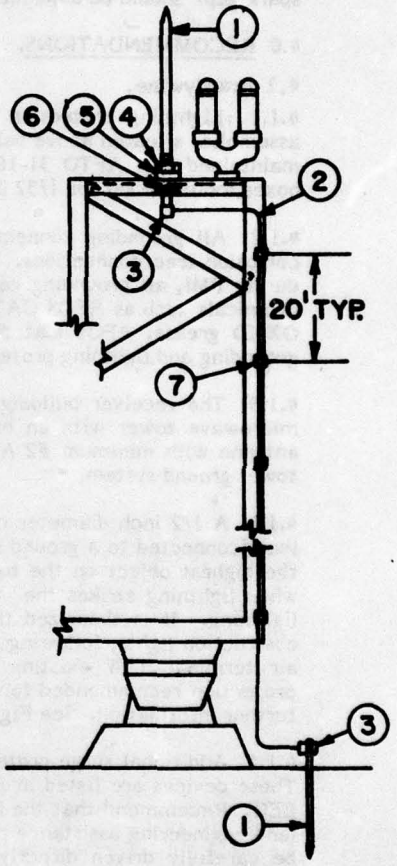
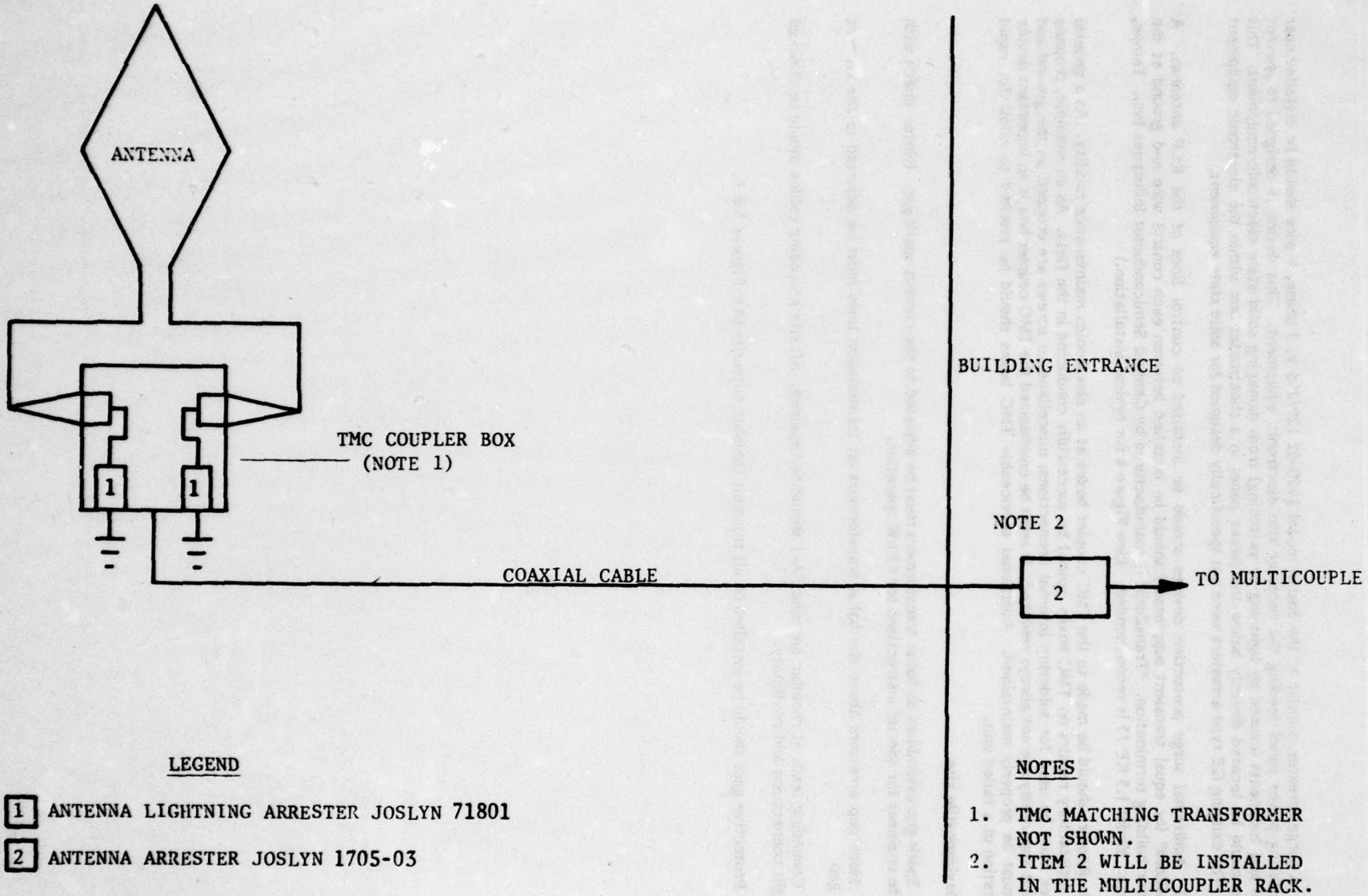


FIGURE 2. TYPICAL LIGHTNING ROD INSTALLATION



LEGEND

[1] ANTENNA LIGHTNING ARRESTER JOSLYN 71801

[2] ANTENNA ARRESTER JOSLYN 1705-03

NOTES

1. TMC MATCHING TRANSFORMER NOT SHOWN.
2. ITEM 2 WILL BE INSTALLED IN THE MULTICOUPLER RACK.

FIGURE 3. RECEIVE RHOMBIC

4.1.9 A surge arrester, similar to the Joslyn model 1420-02 120/208 V, 3 phase, 4 wire should be installed near the existing power panel feeding the receiver site electronic equipment. This device is designed to prevent surges and transients (caused by lightning or switching) from damaging solid state electronic equipment. This device could be located directly below the power panel in a sheetmetal box within the electronic equipment area. The existing GE type arresters were not specifically designed for solid state equipment.

4.1.10 Additional surge protection devices should be installed on control lines of the RLP antennas. A "TransZorb" (or equal transient suppressor) should be installed between each control wire and ground at the receiver building termination. "TransZorb" is manufactured by General Semiconductor Industries Inc., Tempe, Arizona. Model 1.5 KE 75 is recommended. (See Figure 4 for typical installation.)

4.1.11 Repairs should be made to the TMC coupler boxes at an electronics maintenance facility. As a general rule, satisfactory repairs on TMC boxes cannot be succesfully conducted in the field. As an example, propane torches must be used for soldering internal connections; miscellaneous screws are dropped on the ground and lost and apparently are not always replaced. It must be emphasized the TMC coupler box is an important device and must be properly maintained. Additional serviceable TMC boxes should be stocked to allow for rapid restoration of a failed unit.

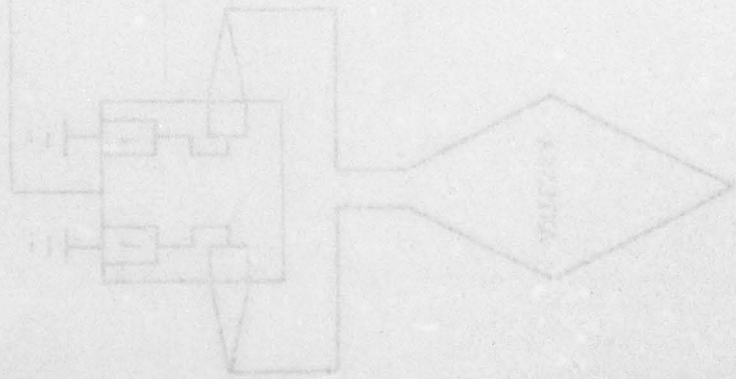
4.2 Davidsonville site.

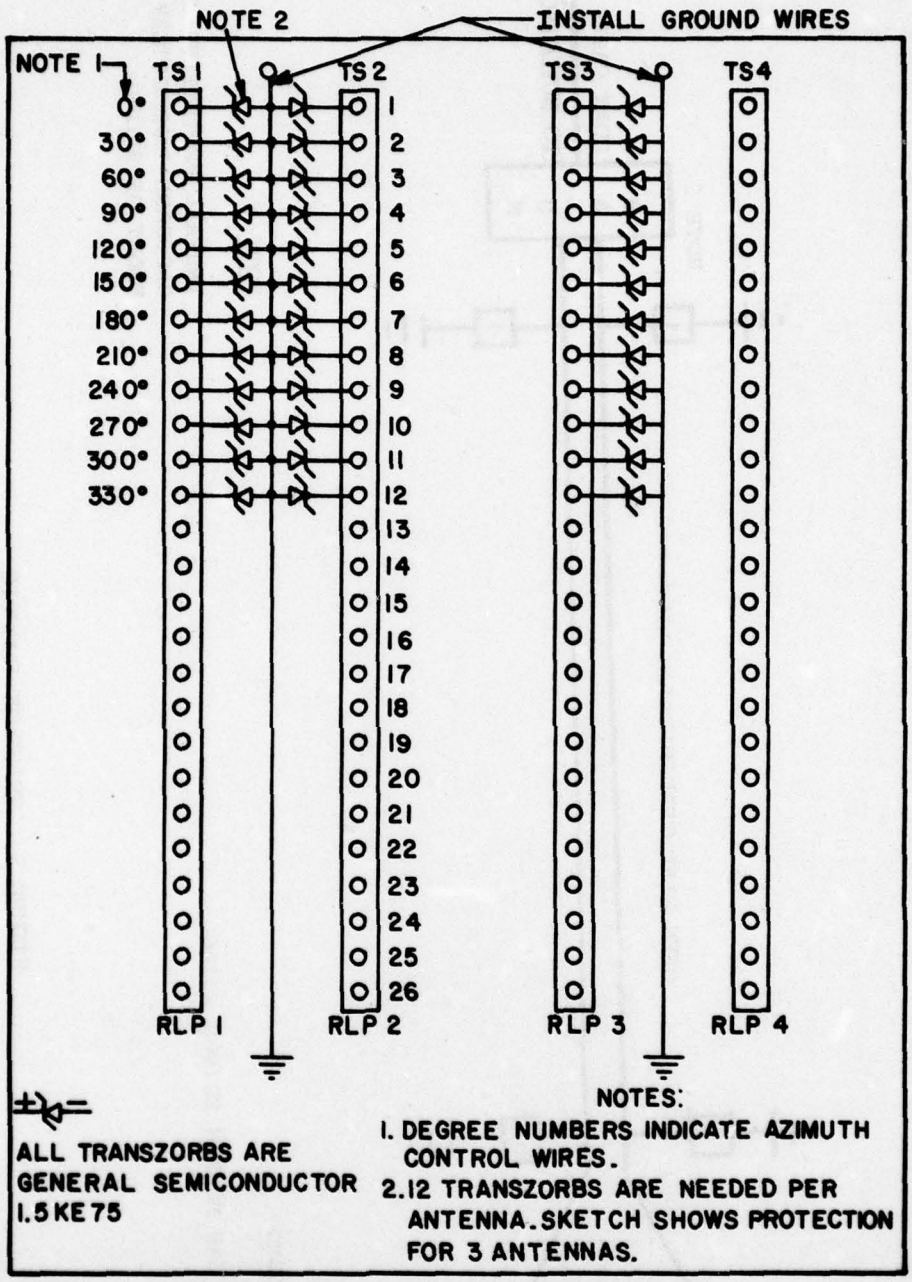
4.2.1 Spark gap assemblies on balun transformers must be adjusted to the correct spark gap. (Note: check with the site engineer for special instructions for 45 kW operation.

4.2.2 Horn gap arresters above the balun transformers on transmission lines must be adjusted to the correct spark gap.

4.2.3 Grounding leads at rhombic antenna FA-1 should be repaired. All site grounding cables should be checked for tight connections and continuity.

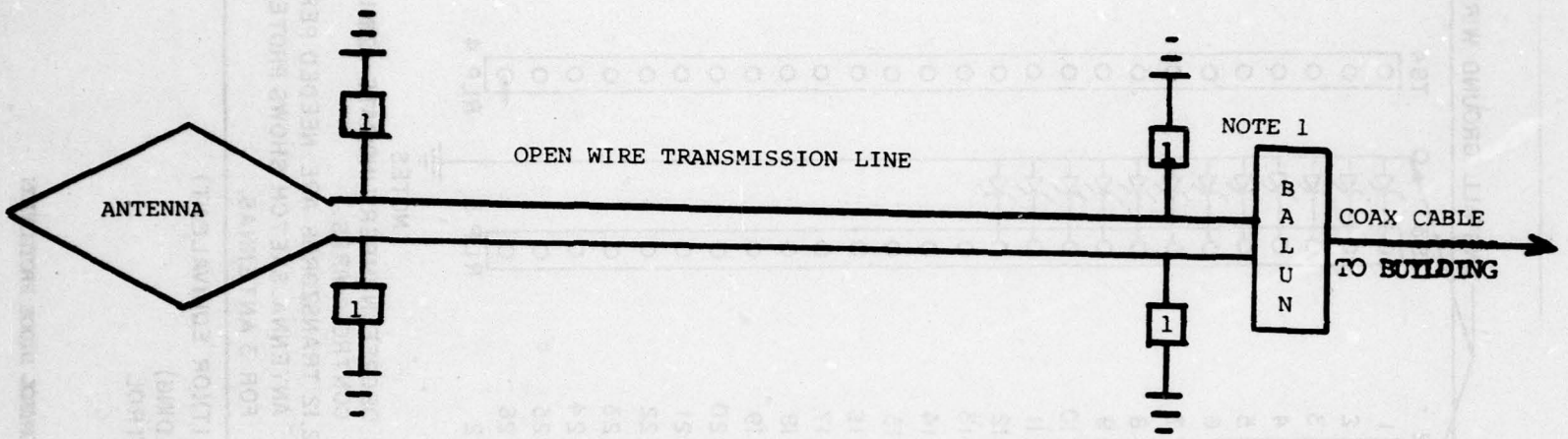
4.2.4 Protective gaps should be installed on all transmit rhombic antennas IAW Figures 5 & 6.





ANTENNA INTERFACE BOX (ZIT)(OR EQUIVALENT)
(LOCATED INSIDE BUILDING)
PART OF SCOPE CONTROL

FIGURE 4. MATRIX CONTROL DIODE PROTECTION



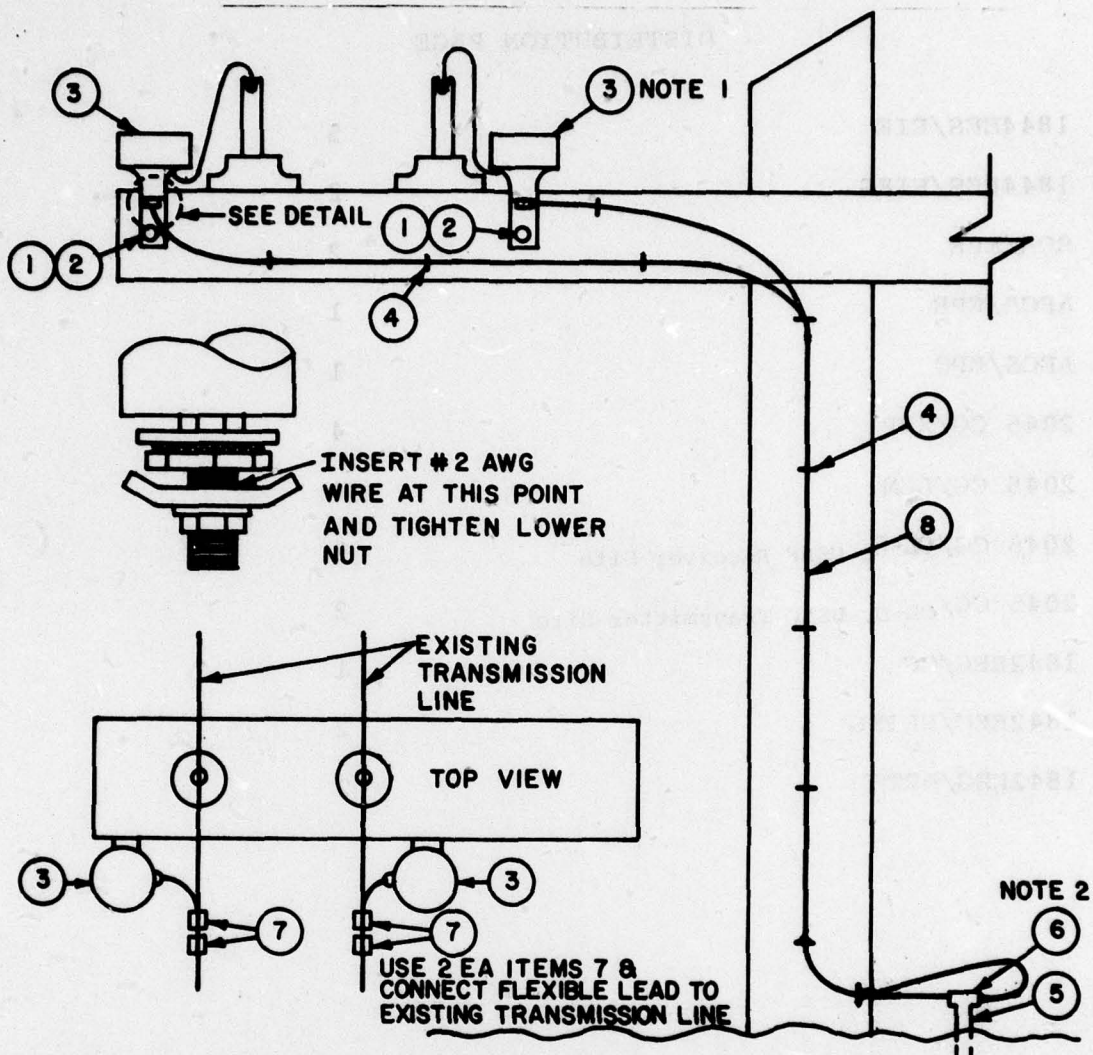
LEGEND

PROTECTIVE GAP MCGRAW EDISON AG1A6

NOTE

INSTALL PROTECTIVE GAPS ON CROSSARM IMMEDIATELY IN FRONT OF BALUN.

FIGURE 5. TRANSMIT RHOMBIC



QTY	CAT #	ITEM	#	QTY	CAT #	ITEM	#
2	3231	LAG BOLT	1	4	1515	SPLICE COND	7
2	2195	WASHER	2	AR	4569	#2 WIRE	8
2	NOTE 3	LIGHTNING ARRESTER	3	1	8498	IGNITER	—
AR	228	STAPLE	4	1	8499	FLINT	—
1	8219	GND ROD	5				
1	8359	T CONN	6				

NOTES:

1. INSTALL LIGHTNING ARRESTERS ON OPEN WIRE TRANSMISSION LINE CROSSARM THAT IS CLOSEST TO THE ANTENNA.
2. REFER TO DWG LDBMS00984AD000 FOR ADDITIONAL INFORMATION.
3. LIGHTNING ARRESTER TYPE AGIA6 (15 KV) BY MC GRAW EDISON.

FIGURE 6. TRANSMIT MONOPOLE LIGHTNING ARRESTER DETAILS

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1844EES/EIE	5
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